Measurement That Works – Really!

J. Wessel
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ASSIP* Measurement Based Acquisition Improvement Initiative

Finding: Acquisition programs incur cost & schedule trouble at some point, at times the status goes from 'Green' to 'Red' in months.

- Sub-optimal outcomes associated with 'ineffective measurement use'
- Investment in measurement diminished or under utilized

Action: Conduct Measurement Based Acquisition Improvement Workshops

- Leverage acquisition management best practices and lessons learned, coupled with SEI measurement body of knowledge.

Outcomes: Greater insights into program and product state.

Phase I - Recommend initial measures & implementation framework
Phase II - Measure Planning & Education delivered; technical assistance provided; progress tracked to goals.

* Army Strategic Software Improvement Program

Army Customers

A list of ASSIP Measurement Assessment customers Include:

- PEO AMMO, PdM MRM

- PEO AVN, 3 APMs: ATNAVICS, MOTS & TAIS

- PEO GCS, PM HBCT

- PEO GCS PM STRYKER

- PEO STRI, PdM OneSAF

- PEO CS & CSS, PM JLTV

- PEO C3T, PD CNI (formerly NetOps)

A SEI technical note has been published (best practices & lessons learned).

http://www.sei.cmu.edu/publications/documents/09.reports/09tn008.html

Two months after a Workshop: an Implementation of recommendations comment-

"the Architecture and Integration contractor and has led to some improvements in our current metrics collection process and data"

Army Acquisition Challenges, And Measurement Based Mitigation

A Life Cycle Perspective…

- Examples, Risk, Instantiation

A System of Systems Perspective…

- Software Performance Example

An Overview of Methods…

Contract Development

Challenge: Provide a clear articulation
of measurement expectations

- • Contractors need Acquisition Leadership guidance
  (e.g., Secure Coding)

• Positions Contractors & Acquisition Mgmt

- • Articulate the entire measurement process;
  Collection, analysis and reporting (periodicity & format)

• Articulate access to data (e.g., IPT members)

- • Specify Completeness, Accuracy, Timeliness (QA)

Avoid being cornered
from the get go

Recommendation:

Start at the RFP Project Phase, review for updates subsequent phases-

Incorporating Software Requirements into the System RFP:
http://www.sei.cmu.edu/library/abstracts/reports/09sr008.cfm, Charlene Gross

Requirements Management: Samples

Challenge: "What's the Work, How did we Spend, How did we Decide?"

Measurement: **Baseline work by <u>Source & Type</u>, better able to manage evolution**
      e.g., New, Fix, External change, Taskers, Re-Work

- **Review the alignment of processes to current requirements state**

Challenge: Requirements change during projects e.g., new customer work

**Measurement: Develop an estimate of change based on history.**

- **Monitor and record requirements or specifications and all changes.**

- **Estimate how much change can be tolerated-**
  Cost/schedule a major concern if new requirements come at a late stage
  (may need to normalize input queue/schedule)

Requirements Management 2 : Representation

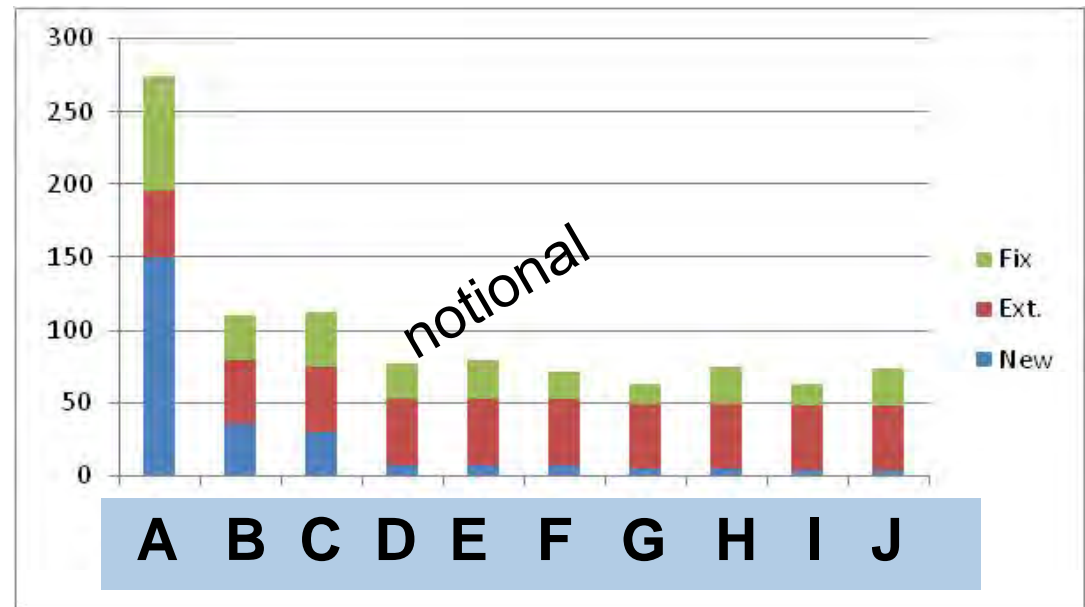Graphical Summary of metrics provides a visible goal.

Total Program Dollars
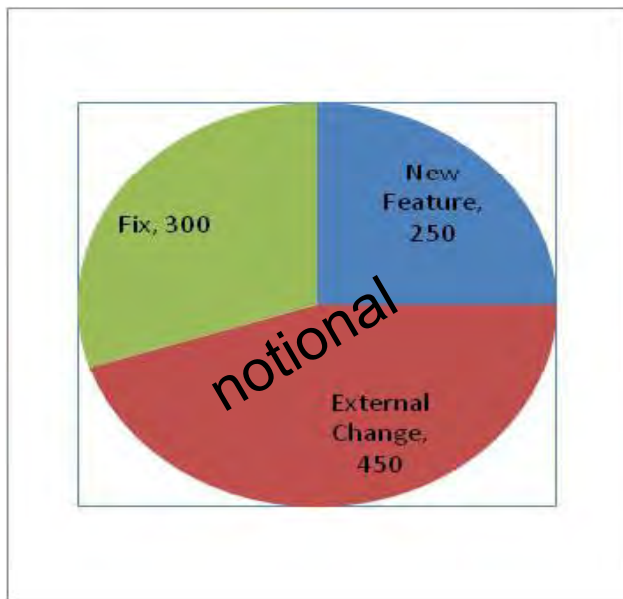
Allocated Cost by Product

Program Level   Or   Product Level

Shows allocation of resources to new features, interoperability, and fixes.

Potential Action: reduce fix costs to add resources to new development

Technology Insertion

Challenge: New technology demands arrive from many Internal and external sources (e.g., GFE/COTs)

Recommend:

• Implement metrics to gauge robustness of <u>technology insertion process</u>.

   • Measure 'ripple effect' potential to understand full impacts (e.g., CM, Test,..)

Measurement Method:

• Measure use of open/commercial interface standards
• Determine own & stakeholder past technology insertion performance (what happened to everyone the last time..)
• Determine currency of current, planned skills matrix

Note: TRLs target the readiness of the technology itself – *not the readiness of the vendor* (which affects all their processes).

Software Development

Challenge: How do I assess Software Development Progress?

Sample measures include:

Component Size -

- Team vs. component size ratio

Development Team performance-

- Team development synchronized, regular integration?

Software Coupling-

- High coupling? Components with highest coupling are also least reliable

Complexity-

- Components w/ top 10% complexity value contain the least reliable code

Traceability Matrix-

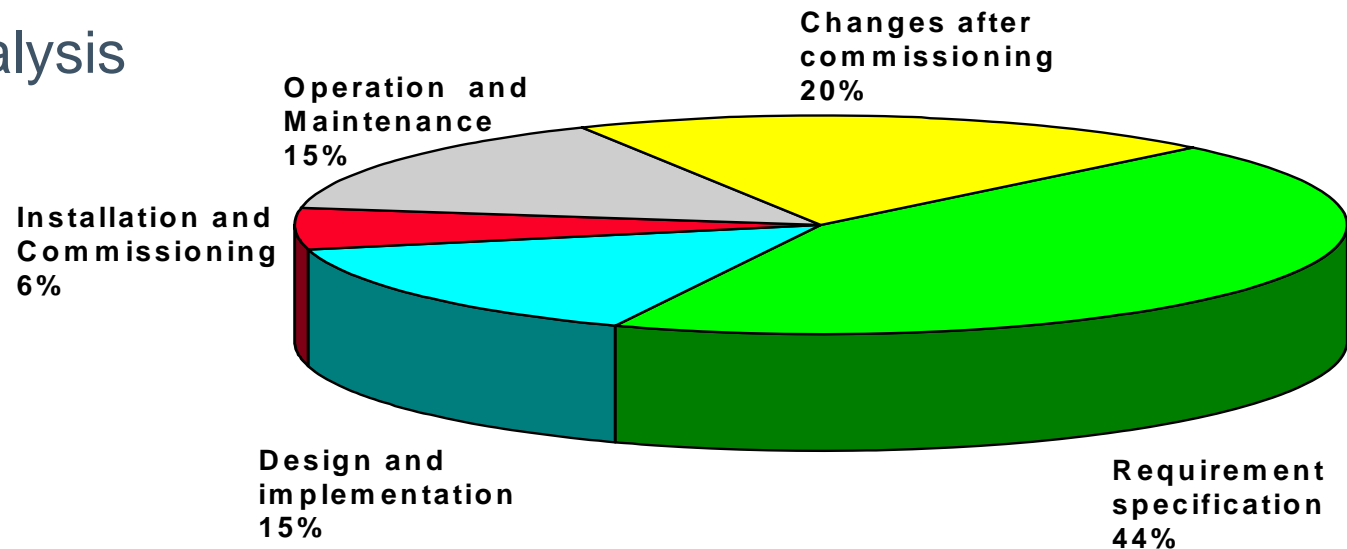- Map SW Components to desired capabilities (gaps decrease over time)

Test Defect Classification

Challenge: How can I use defects collected?
(contractor has a form of defect data residing in a database).

Action: Classify Defects, determine trends and action response.

- Measure Defect rate, origin & found phase (e.g., code)

- Initiate Causal analysis

  (categorize!)

- Trend analysis

Changes after commissioning 20%

Operation and Maintenance 15%

Installation and Commissioning 6%

Design and implementation 15%

Requirement specification 44%

Use/Benefit:

- Continual quality improvement
- Schedule and cost improvement (catch bugs early, focused QA)
- Reduce re-work, Useful for Reliability Estimation

Quality Assurance (QA)

Challenge: Do activity 'checkmarks' make the grade?

Few PMOs have QA activity internally or require QA results from suppliers.

- Provide evidence that Supplier & PMO following their defined processes.

- Provide a (needed) holistic perspective on a program.

Recommendation: evaluates the following (measures):

- Defined process for desired data collection

- Adherence to process practice

- Quality of process (how well is it working)

- Measurement data quality (e.g., source: raw or derived)

- Risks discovered (associate risk to findings, mitigation status)

Measurement Infrastructure

Challenge: PMOs cant afford to fully fund measurement

Measurement is not free. Infrastructure needed to support data collection and generate regular analysis/reports for distribution.

PMOs resources are limited, programs have significant priorities to balance, battle rhythm is fast sometimes leaving measurement behind.

- Most PMOs have little experience implementing measurement, hence the work of measurement falls by default into the hands of the contractor.

Action: Request Assistance-

- Data Repositories
- Training, PMOs can group measurement skill updates
- Assist resourcing for SEC support

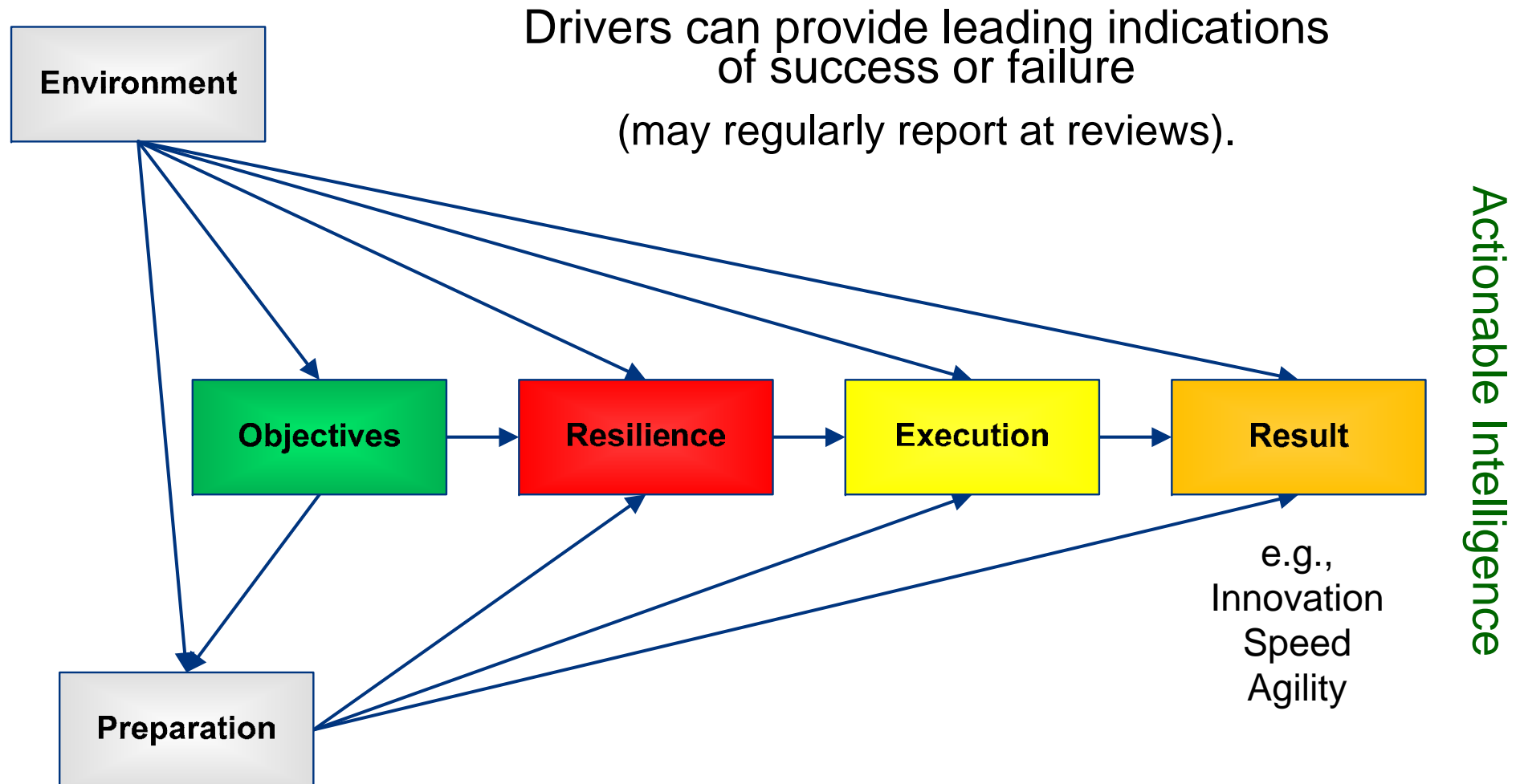 (local experts can be utilized more effectively and efficiently)

Risk Management

Challenge: Are Risks Monitored, Are key SW risks escaping?

- Risks proposed by an engineer may be seen as "engineering problems"

  - Mitigation not considered early, program is unprepared later on.

- Risks are not prioritized at the right level for action.

  - If mitigation is too costly for the team, the risk should be escalated.

- Monitor potential risks to retirement.

  - Risk profile should decline as more is learned about the project and the product.

- **Monitor Program Risk Drivers**

Risk : Categories Of Mission Risk Drivers

Drivers can provide leading indications of success or failure

(may regularly report at reviews).

Environment

Objectives → Resilience → Execution → Result

Preparation

e.g.,
Innovation
Speed
Agility

Actionable Intelligence

Audrey Dorofee: http://www.sei.cmu.edu/library/abstracts/reports/09tr007.cfm

Risk : Categories Of Mission Risk Drivers 2

Objectives

1. Program Objectives

Preparation

2. Plan
3. Process

Execution

4. Task Execution
5. Coordination
6. External Interfaces
7. Information Management
8. Technology
9. Facilities and Equipment

Environment

10. Organizational Conditions
11. Compliance

Resilience

12. Event Management

Result

13. Deployment meets readiness criteria
14. Installed components are known (CM)
15. Product configuration is adapted to unit
16. Network has sufficient capacity
17. System is satisfactorily supported in field
18. Certification and accreditation

Example

Organizational SW Staff Integration

Recommendations: Monitor Integration of SW Staff/Data in PMO

• Invite SW Leads to report key SW Metrics at regular PM meetings,

relate to key PMO tracking areas e.g., SW Team Performance

Program Office Functions

Oversight	Control	Planning
Communications Funding vs Need Track to Schedule Progress to Plan Spend to Plan Risk	**Decisions** Change Request Evaluate Performance Evaluate Product Select Vendor Risk **Action** Incentive Payments Change Orders Award Fee Establish Contract	Team Performance Estimate Effort Estimate Duration Estimate Progress Allocate Resources Schedule Create EVMS Mitigate Risk

Associated to overall (SE) Goals

SW Team
Performance Measures

Plans	Progress
Resources Available Milestones Size Quality Requirements	Effort Milestones Size Completed Quality Requirements Coverage

SW Data Utilized
(Core Metric Consideration)

Army Acquisition Challenges,
And Proposed Mitigation

A System of Systems Perspective…
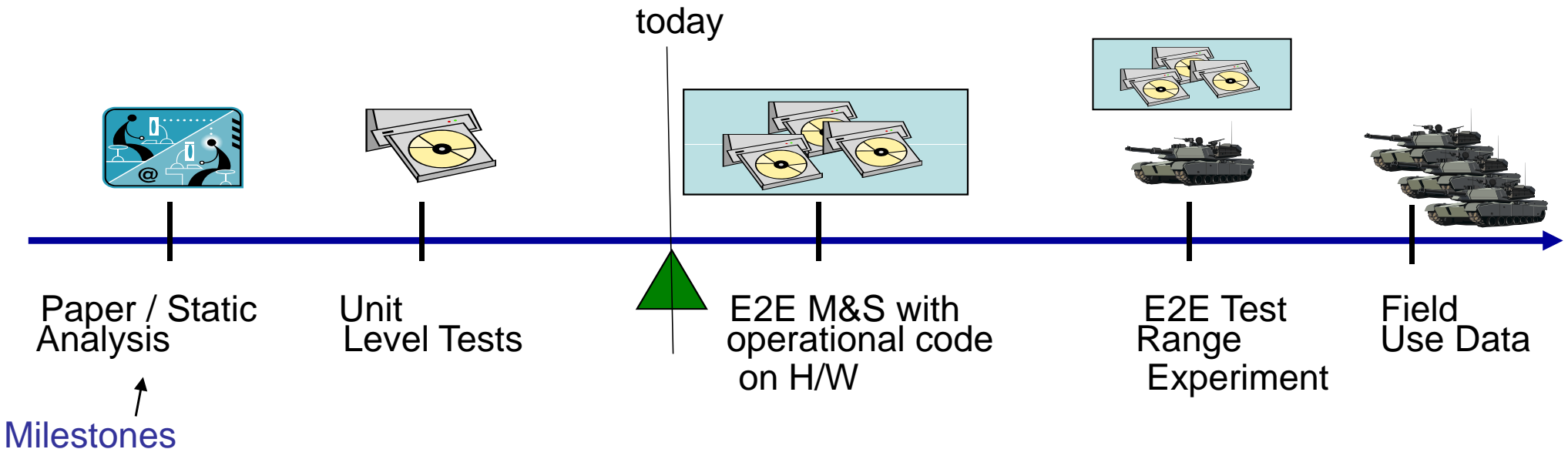
A Driving Acquisition Management Challenge:

"Will Software under development [e.g., algorithms] enable planned capabilities in a full-up E2E operational environment."

A SOA based SoS case example…

A Software Performance Measurement Perspective

Challenge: "If I wait until formal test events (e.g., LUT), its late to make too many adjustments"

today

Paper / Static
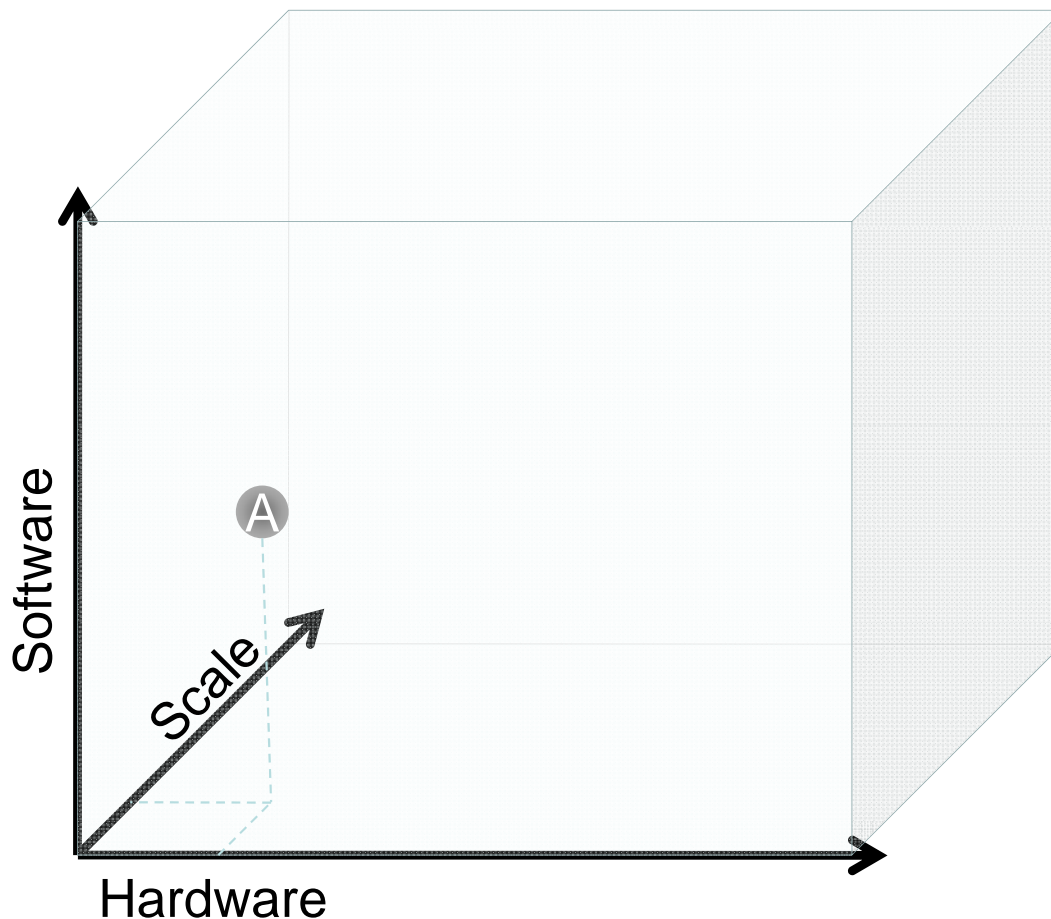Analysis

Unit
Level Tests

E2E M&S with
operational code
on H/W

E2E Test
Range
Experiment

Field
Use Data

Milestones

~ Notional Roadmap ~

For each 'milestone', track deliverables to activities at varied levels:
- Artifacts e.g., Software resource usage / system
- Need "good enough" criteria to move to next phase

Managing SWP Progress 1

Track Metric Maturity

Uneven progress will be visible

Three Axis per test event:

1.Software:
- Mod=Modeled
- Sim=Simulated
- Proto=Prototype
- EB=Early Build
- LB=Later Build
- Mat=Mature

2.Hardware:
- Sim=Simulated
- EP=Early Prototype
- LP=Late Prototype
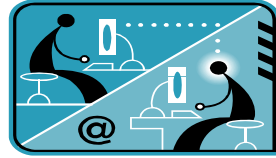- IP=Initial Production
- FP=Full Production

3.Scale:
- SB/MB=Single Blade/Multiple Blades
- PU/MPU=Processing Unit/Multiple PUs
- SS=Single System
- LS=Limited Multiple System
- PS=Partial Scale
- FS=Full Scale

Managing SWP Progress 2

Two Complimentary Performance Views

Discrete Event View
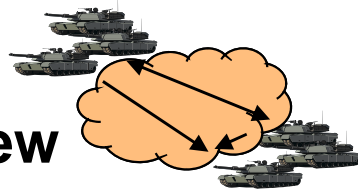
Will SW enable each operational task, as needed, for the duration of the task.

- At Thread / Step level, determine feasibility

Representative Metrics:

- CPU & RAM Utilization
- Process LAN connectivity
- Process Client Calls (as applicable)
- Process Prioritization
- Process MiddleWare Calls
- Software Threads

Enterprise (SoS) View

Will SW enable concurrent operational demands across the SoS?

- For all processes, determine feasibility

- Process Count / System Threads
- Blade to Blade Calls
- Platform LAN utilization
- Client calls over WAN
- CPU traffic to Drives

Managing SWP Progress 3

Establish a SWP IPT: This is not a one person job within large SoS environments (too complex).

Potential goals:

- Align/ratify SWP planning to strategic goals

- Improve (common) understanding and use of SWP measures

- Instantiate an infrastructure to accommodate SWP plan tasks

    - e.g., Resources, effective/efficient data collection, analysis, presentation processes/workflows

SWP IPT Best Practice 1

Common SWP Metric Matrix: Implementation Tool for Activity Leads
– Help ensure consistent implementation/use across SoS

| Metric Title	Why?	How?	Need Type	High Level Type
Error Logging and statistics	Which combinations of services and clients+ Apps under which conditions cause issues at the system and application level. SYSLOG, SNMP, OS Capture	Instrumentation of code w/process to service to above metrics + log parser+ statistical analysis	Efficiency	Engineering
I/O bus access count	Used to derive proxy and other efficiencies. Can software (per application/client/proxy) consolidate requests to the drives, can it minimize access to off-blade devices. Can requestors minimize requests to a service on a blade?	Repeated capture from OS	Efficiency	Engineering
Instances/Client/situationInstances/Service/situation.	Check for Process Clean up, Avoid hung processes, Minimize Instances	Process-Message snapshots and parse	Efficiency	Engineering

SWP IPT Best Practice 2

Capture End-To-End Performance

- **Mapping helps to ensure adequate, trace-able, End-to-End Performance.**

- **Capability (Mission) to SoS (e.g., Services), through System (e.g., Use Cases) and eventually Component (Threads) level traceability**

Tie to Goals (for example)-

1. Throughput (how much),

2. Latency (how fast), and
3. Computer resources (using what resources)
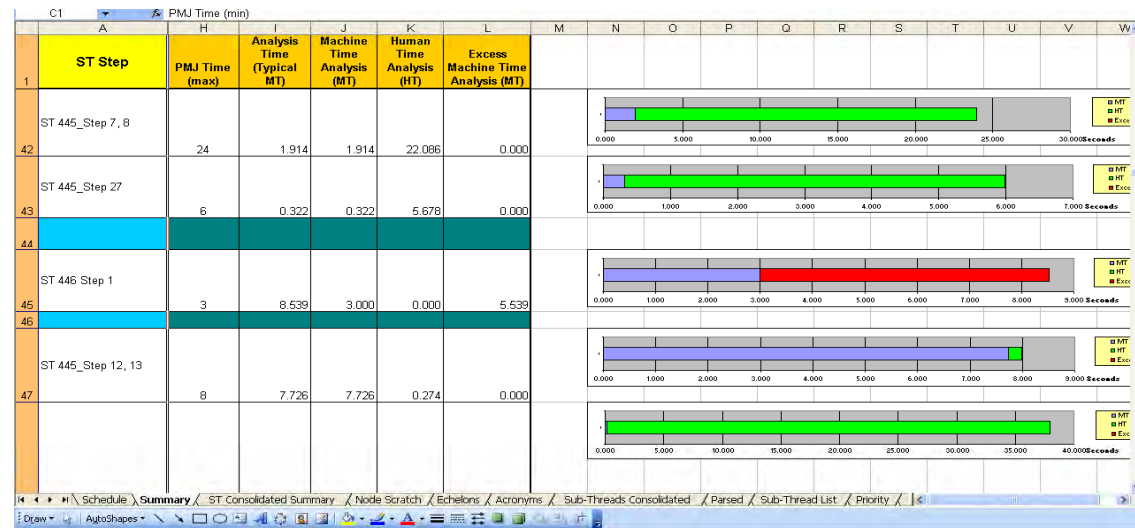
Utilize existing resources and test assets

Method Overview –
Implementing Program Measures

Method (Option I):

- **Develop basic measures associated to:**

  — Predictability, Scope and Change, Product Quality, Product Assurance and Process Effectiveness

  — obtain alignment with specific and unique project goals.

- **Analyze contractor practice for suitability and application.**

  — (Optional) negotiate for additional data.

- **Transform contractor data into indicators for program use.**

- **Identify required internal data.**

- **Implement required internal process for data collection and reporting.**

Developing Leading Indicators

Specific, risk-based, time-dependent measures

Method (Option II)

Same as prior

- **Introduction describes the basic measures associated to:**
  - Predictability, Scope and Change, Product Quality, Product Assurance and Process Effectiveness

- **Restate specific and unique project goals with measures.**

Different

- **Identify project specific risk-drivers (broader than risks).**

- **Use prepared table to link risk-driver to project-activity.**

- **Use prepared table to link goal-to-activity-to-indicator.**

- **Implement data collection and reporting.**

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SSTC 2010
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Specialized Measurement Techniques

Review basis of estimate

Analyzing Technical Progress (converging or not)

- Method for conducting a technical review (e.g. PDR) and providing a valuable report.

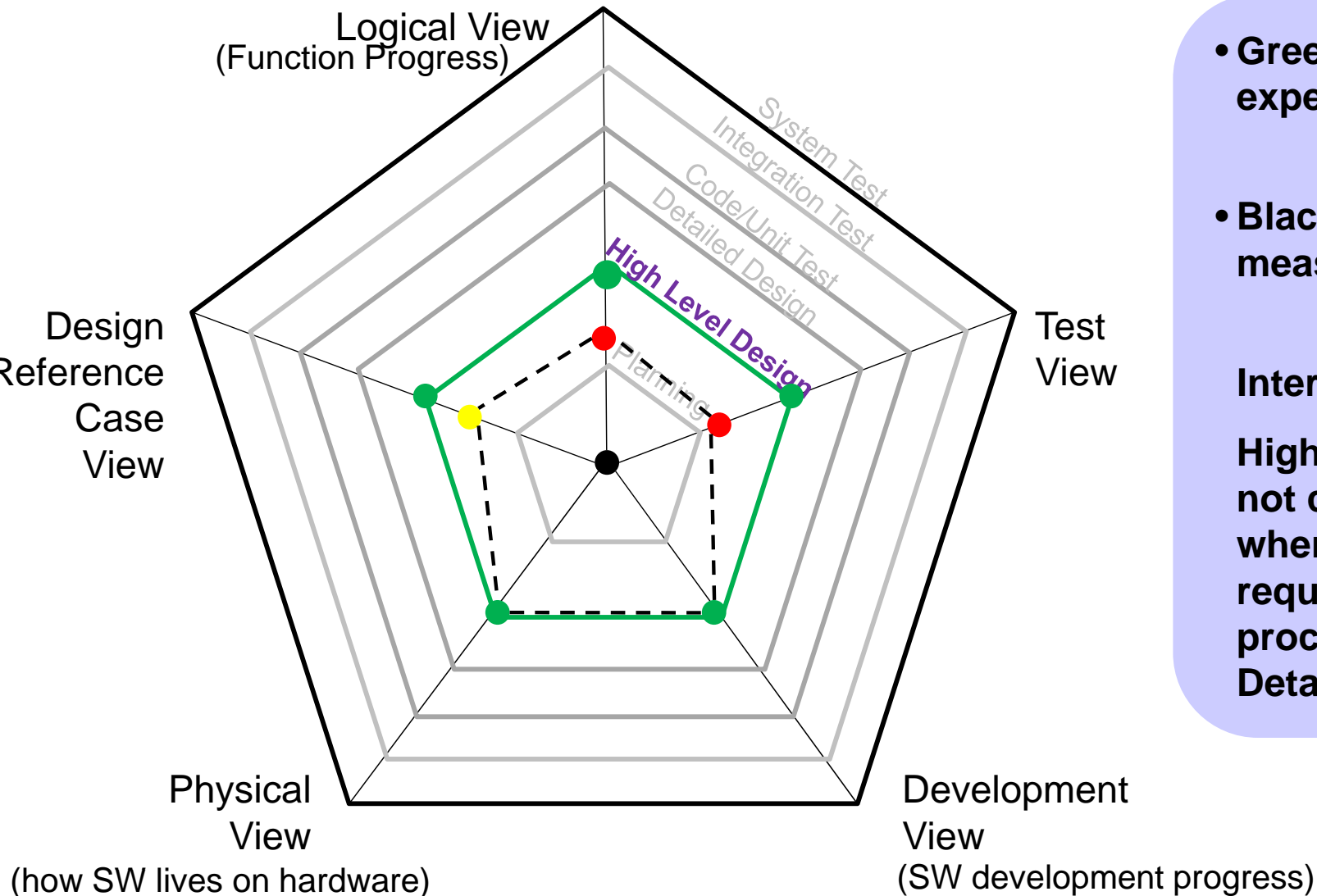- Improved effectiveness by analyzing available process information.

Technology Readiness Level (TRL) and Technology Adoption

- Supplementing TRLs with technology adoption and technology manufacturing readiness assessment.

The Technical Progress Indicator

"Radar" Chart : Design Milestone Review (example)

- **Green - indicate expected values**

- **Black - indicate the measured values**

Interpretation -

High Level Design is not complete, shows where resources are required before proceeding to Detailed Design work

Summary

The targeted application of a few measures can provide significant 'actionable intelligence' to program managers to illuminate issues and aid the decision making process toward remediation.

- Must be aligned to the program's business needs

- Relating measures to program risk a powerful communications tool

The complexity inherent in large, SoS acquisitions can overcome a program's ability to understand software performance progress. Planning for software performance measurement management early in the program lifecycle can aid managers in delivering software that provides intended capabilities, within end-to-end user environments.

Acronym Slide

AMMO	- PEO AMMO Ammunition
ASSIP	- Army Strategic Software Improvement Program
AVN	- PEO Aviation
C3T	- PEO Command Control Communications Tactical
CM	- Configuration Management
COTS	- Common Off The Shelf
CPU	- Central Processing Unit
CS&CSS	- PEO Combat Support and Combat Service Support
DoD	- U.S. Department of Defense
E2E	- End-to-End
EIS	- PEO Enterprise Information Systems
GAO	- U.S. General Accounting Office
GCS	- PEO Ground Combat Systems
GFE	- Government Furnished Equipment
H/W	- Hardware
IEW&S	- PEO Intelligence Electronic Warfare and Sensors
IPT	- Integrated Product Team

Acronym Slide 2

LAN	**- Local Area Network**
LUT	**- Limited User Test**
M&S	**- Modeling and Simulation**
PEO	**- Program Executive Officer**
PM	**- Army Program Managers**
PMO	**- Program Management Office**
QA	**- Quality Assurance**
RAM	**- Random Access Memory**
RFP	**- Request For Proposal**
SE	**- Systems Engineering**
SEC	**- US. Army Software Engineering Center**
SoS	**- System of Systems**
STRI	**- PEO Simulation, Training and Instrumentation**
SW	**- Software**
SWP	**- Software Performance**
TRL	**- Technical Readiness Level**
WAN	**- Wide Area Network**

Backup

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Sample Software Core Measures

Core measure	Definition
Schedule	Measures either task duration or task start and task completion. It is essential that everyone involved agrees on the definitions and how the tasks and events are measured.
Effort	Measures time spent by assigned resources. By monitoring effort it is possible to observe overburdened resources as well as understanding program costs.
Size	Size may represent either the size of the deliverable or the size of the inputs. LOC, the typical software measure of size, is a deliverable measure. Many use Equivalent Lines of Source Code (ESLOC), a mechanism for normalizing code size across different teams and different technologies.
Defects	Defects as reported by inspections, tests and other quality assurance activities provide a great deal of information about program product and process risk.
Requirements	Counts of requirements provide information about the rate of change of the product and the customer environment.

These core measures contribute to project reporting, the analysis of team performance, and change management.

For Program Office Functions, The data used to construct indicators are mostly the core measures.

Contact Information

Presenter / Point of Contact

Jim Wessel

Acquisition Support Program

Telephone: +1 908-418-0323

Email: jwessel@sei.cmu.edu

World Wide Web:

www.sei.cmu.edu

www.sei.cmu.edu/contact.html

U.S. mail:

Software Engineering Institute

Customer Relations

4500 Fifth Avenue

Pittsburgh, PA 15213-2612

USA

Customer Relations

Email: customer-relations@sei.cmu.edu

Telephone: +1 412-268-5800

SEI Phone: +1 412-268-5800

SEI Fax: +1 412-268-6257